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TECHNICAL SUMMARY

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PROJECT COST:
$44,369

Self-cementing materials such as fly ash are mixed into subgrade soils to strengthen and stiffen them.

Quantifying Subgrade Stabilization's Improvement of Pavement Performance

The results of this project will help engineers design more cost-effective pavements by establishing mechanistic-empirical design parameters for the resilient modulus of underlying soils that have been stabilized with various materials.

What Was the Need?

To help improve the constructability and performance of Minnesota's roads, MnDOT often uses stabilizing materials to increase the strength and stiffness of the subgrade soils supporting the pavement. Typical additives include cement, foamed asphalt, lime and recycled materials such as shredded tires and fly ash, a byproduct of coal-burning plants. These materials facilitate construction and reduce the need for future maintenance.

While the use of these stabilizing materials has become more common in Minnesota, there has been no comprehensive quantification of how well they improve a soil's resilient modulus, a measure of stiffness. Resilient modulus is an important input for mechanistic-empirical design, a method that uses mathematical models to predict pavement performance from the properties of the materials used to construct them, along with other factors such as traffic and weather conditions. Because the effects of stabilization are not well-known, engineers currently use the resilient modulus of unstabilized soil as an input even for stabilized roads, leading to pavements that are thicker and more costly than necessary. Establishing improvement factors for stabilization methods would help to refine this parameter, allowing more cost-effective pavement design.

What Was Our Goal?

The objectives of this project were to investigate methods and materials for stabilizing pavement subgrades and to establish mechanistic-empirical design parameters for the resilient modulus of stabilized roads.

What Did We Do?

Researchers began by conducting a literature review and consulting a technical advisory panel to identify stabilization materials and techniques that have been used by MnDOT and local Minnesota agencies. Then they identified those materials and techniques of greatest utility to MnDOT and local agencies, and reviewed past research projects to evaluate them. This review focused on the design properties of stabilized materials from field and laboratory testing in previous research and included identifying available resilient modulus data for stabilized materials.

Because of variations found in the literature regarding the degree of stiffness improvement resulting from various factors, researchers developed a testing procedure to allow stabilized soils' stiffness values to be obtained on a project-by-project basis. These values can be used in the design phase to optimize pavement design.

What Did We Learn?

Researchers produced a comprehensive list of stabilization materials and techniques, and selected those of particular interest to MnDOT and local agencies, including various combinations of fly ash, cement, lime, gypsum and phosphogypsum, slag, polymers, pond ash, cement kiln dust, foamed asphalt and bitumen, and emulsion.

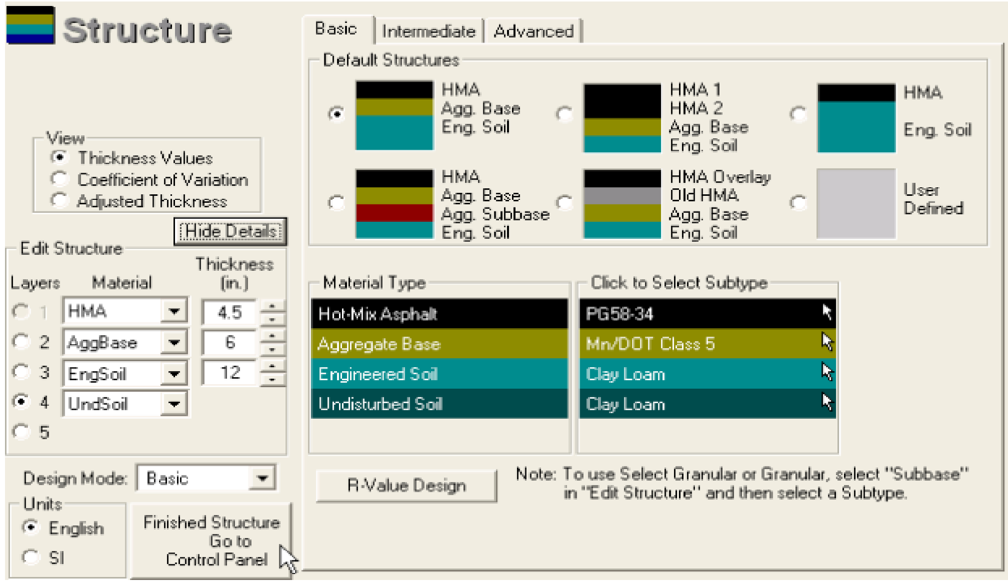
continued

"Establishing resilient modulus improvement factors for stabilized pavements will help in the design of better-performing, more cost-effective roads."

—Shongtao Dai,
Research Operations Engineer, MnDOT Office of Materials

"Currently engineers use parameters for nonstabilized materials when designing stabilized roads, leading to pavements that are more costly than necessary."

—Aaron Budge,
Associate Professor, Minnesota State University, Mankato, Department of Mechanical & Civil Engineering



Using software such as MnPAVE (which predicts the service life of a pavement from climate, traffic and structural data) to determine how stabilization improves pavement stiffness is important to mechanistic-empirical design.

The literature review showed that where data exist, there is a large variability in the degree to which stabilization improves the strength and stiffness of subgrade materials. This is due to variation in the amounts of stabilization material added to soils as well as subgrade properties such as moisture content, stabilization agent content, soil type and other variables.

In light of this variability, researchers considered it impractical to identify one factor of improvement to estimate the stiffness properties for a combination of material and stabilization method. Instead, they recommended that a procedure be followed on a project-by-project basis to identify an appropriate stiffness resistance factor during the course of project predesign and design. For each project, two mix designs should be created to identify the appropriate proportions of soil, water and stabilization material required to obtain the desired strength and stiffness properties: one with untreated subgrade material and the other with stabilized material. The resilient modulus should be established for both the stabilized and unstabilized materials so that a database of local and regional soil types and stabilization methods can be developed. Collecting this data will eventually allow MnDOT to establish a more general set of improvement factors for various stabilization techniques.

To show that the stiffness values obtained from lab testing are achieved in the field, researchers also recommended conducting field tests both during and after construction using the lightweight deflectometer and dynamic cone penetrometer. Long-term tests should also be conducted using the falling weight deflectometer to show how stiffness changes with time and to assist in determining long-term pavement performance.

What's Next?

The developed procedure can be used in the future for MnDOT's mix designs. This will allow MnDOT to improve its pavements by controlling stabilized material quality for subgrades.

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